French Meadows Hydrology Report

PREPARED FOR:

U.S. Forest Service
Tahoe National Forest
American River Ranger District

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Introduction

This report will analyze the potential effects of the French Meadows Project (FMP) on the water resources within the Tahoe National Forest (TNF). For detailed descriptions of the project refer to Chapters 1 and 2 of the French Meadows Project Environmental Assessment (EA).

Analysis of the effects is based on indicators of compaction and soil/canopy cover, and analogously, results of Forest Service Cumulative Watershed Effects (CWE) analysis. Discussion is provided in the "Analysis Area/Analysis Indicators" section of this report. The Tahoe National Forest (TNF) Land and Resource Management Plan (LRMP) (USDA 1990), and Forest Service Technical Guide FS-990a, National Core BMP Technical Guide (USDA 2012), provided guidance for project Management Requirements (MR) (see chapter 2 of the FMP EA)**.**

Regulatory Framework

The LRMP as amended by the Sierra Nevada Forest Plan Amendment (SNFPA) (USDA 2004) provides the base for policy and regulation though standards and guidelines. Best Management Practices (BMPs) will be drawn through the National Core BMPs (USDA 2012). The Management Requirements (MRs) specific to this project largely adhere to LRMP Standards and Guidelines and Core BMPs. Table 1 shows applicable National Core BMPs and corresponding MRs developed for the project. The MRs are described in Chapter 2 of the FMP EA. Pursuant to the Clean Water Act (CWA) (1972) the state of California releases a biennial report identifying impaired water bodies; the 2012 report is the latest update.

Table 1. Summary of applicable National Core BMPs and corresponding MRs

Best Management Practice	Management Requirement
Veg-3, Veg-6	W1-2, W12-13
WatUses-1	W6-9
Chem1, Chem-4	W5, W12
Fire-1, Fire 2	W3-4
Road-3, Road-5, Road-6, Road-10	W2, W10, W13-14

Working cooperatively with the California State Water Quality Control Board, the Forest Service developed pollution control measures, referred to as Best Management Practices (BMPs) that are applicable to National Forest System lands. The BMPs were evaluated by State Water Quality Control personnel as they were applied on site during management activities. After assessment of the monitoring data and completion of public workshops and hearings, the Forest Service's BMPs were certified by the State and approved by the Environmental Protection Agency (EPA) as the most effective means to control non-point source pollution.

> The Regional Water Quality Control Board, Central Valley Region (CVRWQCB) adopted Order R5-2017-0061 which serves as general waste discharge requirements (WDRs) for waste discharges related to timberland management activities on federal

lands that could affect waters of the state. To be eligible for coverage under this order, the project has met the definition of timber management activities, and would comply with all of the applicable eligibility criteria, terms, and conditions. The eligibility criteria include:

1. USFS has conducted a multi-disciplinary review of the timber harvest proposal, including review by watershed specialists, and has specified best management practices (BMPs), and additional control measures as needed, in order to assure compliance with applicable Basin Plan.

2. USFS has conducted a cumulative watershed effects (CWE) analysis and included specific measures needed to reduce the potential for CWEs in order to assure compliance with applicable water quality control plans.

3. USFS has allowed the public and other interested parties reasonable opportunity to review and comment on and/or challenge individual timber harvest proposals.

This project has complied with all the “Eligibility Criteria” and “Conditions” specified in the Order.

Riparian Area Management

The SNFPA requires that a site-specific project-level analysis be conducted to determine whether activities proposed within Riparian Conservation Areas (RCAs) meet the Riparian Conservation Objectives (RCOs). This analysis examines how well the Proposed Action for the project meets the Riparian Conservation Objectives and/or how it would bring the project area closer to meeting these objectives. The objectives and discussion on compliance are located in the Appendix of this report.

Standards and Guidelines

The following Standards and Guidelines (S&Gs) are specific to water resources, and are in the LRMP pp. V-33 to V-35.

#43: Cumulative Watershed Effects Analysis. A Cumulative Watershed Effects (CWE) analysis will be performed for each 7th level HUC (Hydrologic Unit Code) 14-digit code (see Figure 1), substituting for the LRMP guidelines for analysis on the basis of 3rd order watersheds. The ERODA program, an Excel-based format, was used to perform an Equivalent Roaded Acres (ERA) method assessment, which normalizes management impacts to equivalent road acres.

#46 and 47: Management for Perennial, Intermittent and Ephemeral Stream Corridors. These standards lay out directions for establishing Streamside Management Zones (SMZ) for the purpose of buffering water courses from management activities. The LRMP was amended by the SNFPA, from which guidelines for SMZ will be used in this project. These guidelines are presented as MR W1 (see Chapter 2 of the FMP EA and discussion below).

#50: Water Quality Protection. This standard directs the use of BMPs from the Forest Service Handbook 2509.22 Soil and Water Conservation (1990); however, the National Core BMPs

(2012) will be substituted. For the most part, these BMPs are replicated as MRs for this project (see Chapter 2 of the FMP EA).

Method of Assessment

To assess the affected environment, mechanical treatment units were traversed. The system roads providing access to the treatment units were driven or walked with attention to crossings and drainage points.

Sixty sample points (measuring soil cover/type, and disturbance) on 30 meter spacing were taken in all units with either commercial thinning and/or mechanical thinning, with the exception of unit 3. A 60 point traverse was also run in the mastication area, and part of the burn area of unit 15. A portion of the unit 1 traverse also covered part of that unit's burn area. A portion of unit 19 (20-25% of the area) was also traversed, though without taking samples. Drainages were noted throughout the units, flow condition, and any road crossings encountered.

The Tahoe National Forest follows the Equivalent Roaded Area (ERA) method for assessing CWE. The ERA method normalizes each activity type to an equivalent acre of road surface (i.e. an acre of commercial thinning, for this project, is equal to 0.13 acre of native surface road area). Being non-specific, the ERA method at once addresses runoff and erosion impacts due to canopy and soil cover loss, as well as compacted or otherwise structurally impacted soil. Therefore the method is analogous to the results and conclusions of comparative watershed studies. These studies show that consistent estimates of cover loss, concomitant with soil disturbance that is relatively undefined, results in peak and total yield flow statistics (Troendle and King 1987, Burton 1997, Troendle et al. 2001, and Grant et al 2008).

Though runoff may be construed as analogous to erosion and sediment delivery to streams or other waterbodies, it is important to note that the ERA method is not spatially explicit. The method does not consider where in relation to a steam course the impact occurs. The ERA assessment area is based on the 7th level or 14 digit code HUC. A threshold of concern (TOC) is applied to each watershed by which percent ERA beyond that threshold may result in measureable and/or observable effects to waterbodies. TOC are result of sensitivity analysis that considers a number of factors to do with runoff process, parameters taken from soil layers (hydrologic conductivity, erosion hazard ratings, extent of rock outcrops), and drainage physical properties, such as total relief and drainage density. The cumulative effects for the existing condition and alternatives is presented in tables 4 to 6 below.

Analysis Area/Analysis Indicators

The analysis area consists of eight 7th level HUC watersheds, shown in Figure 1. The activity area is largely within three watersheds: Dolly Creek, French Meadows Reservoir, and Rice Creek. Indicators of soil compaction and cover loss are implicit to the CWE method. These measures were also made in unit surveys. The measures and results in canopy reduction from proposed treatments can be compared to results of a century of comparative watershed studies of harvested ground in the National Forest System. Estimates from research of canopy reduction by mechanical operations and under-burning provide a useful guide to thresholds of activity beyond which measureable or observable effects to flow regime might be expected. These estimates are also analogous to the ERA methodology.

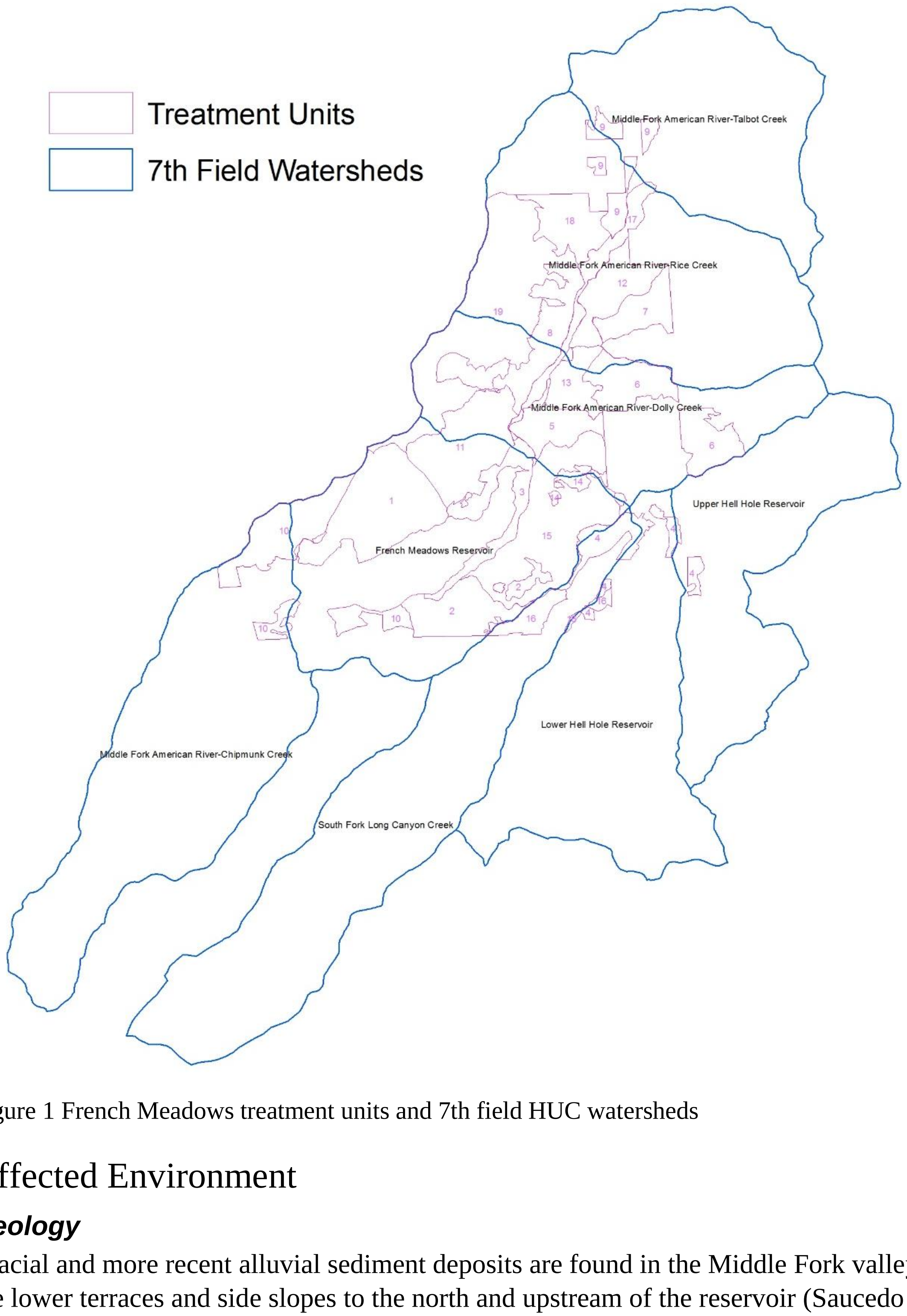

Figure 1 French Meadows treatment units and 7th field HUC watersheds

Affected Environment

Geology

Glacial and more recent alluvial sediment deposits are found in the Middle Fork valley, and in the lower terraces and side slopes to the north and upstream of the reservoir (Saucedo and

Wagner 1992). A thin band of glacial deposit runs along the entire eastern edge of the reservoir as well. Cretaceous granite is mapped as bedrock along the upper margins of valley/lower slopes, north of the reservoir—outcrops of granite are prominent in units 5 and 8. The rest of the ridges are occupied by tertiary volcanics—rhyolite and basalt flow rock, and stratigraphically above, a lahar, or mudflow, of the Mehrten Formation. The Mehrten forms bluffs on the western (Red Star) ridge, occupying as much as the upper half of that ridge. Slope wash fans eroded from the Mehrten also create the deepest soil mantle in the project area, and the most productive ground for trees. A white, tuffaceous ashfall layer runs through the tertiary rhyolite and is a source of springs, as well as a degree of slumping, particularly where it is exposed in roadcuts.

Stream Flow

The northwest facing Chipmunk ridge has numerous live streams; unsurprisingly, the southeast-facing Red Star ridge has only one encountered in the survey. Piped crossings of principal channels and system roads, open or closed, were found adequate to convey flow, but invariably caused scour and hydraulic drops on the downside, and channel aggradation on the upside. Flow was on the order of a few gallons per minute to a minor fraction of a cubic foot per second. None of the streams appeared fish-bearing. It is unknown what other aquatic organisms of interest may inhabit the area channels, and therefore whether any of the crossings pose a passage issue. Stream beds are steep and cobble/boulder dominated, with a step-pool profile. Material was loosely packed and mostly clean, indicating flow every year, probably with peaks during snow melt (April-June).

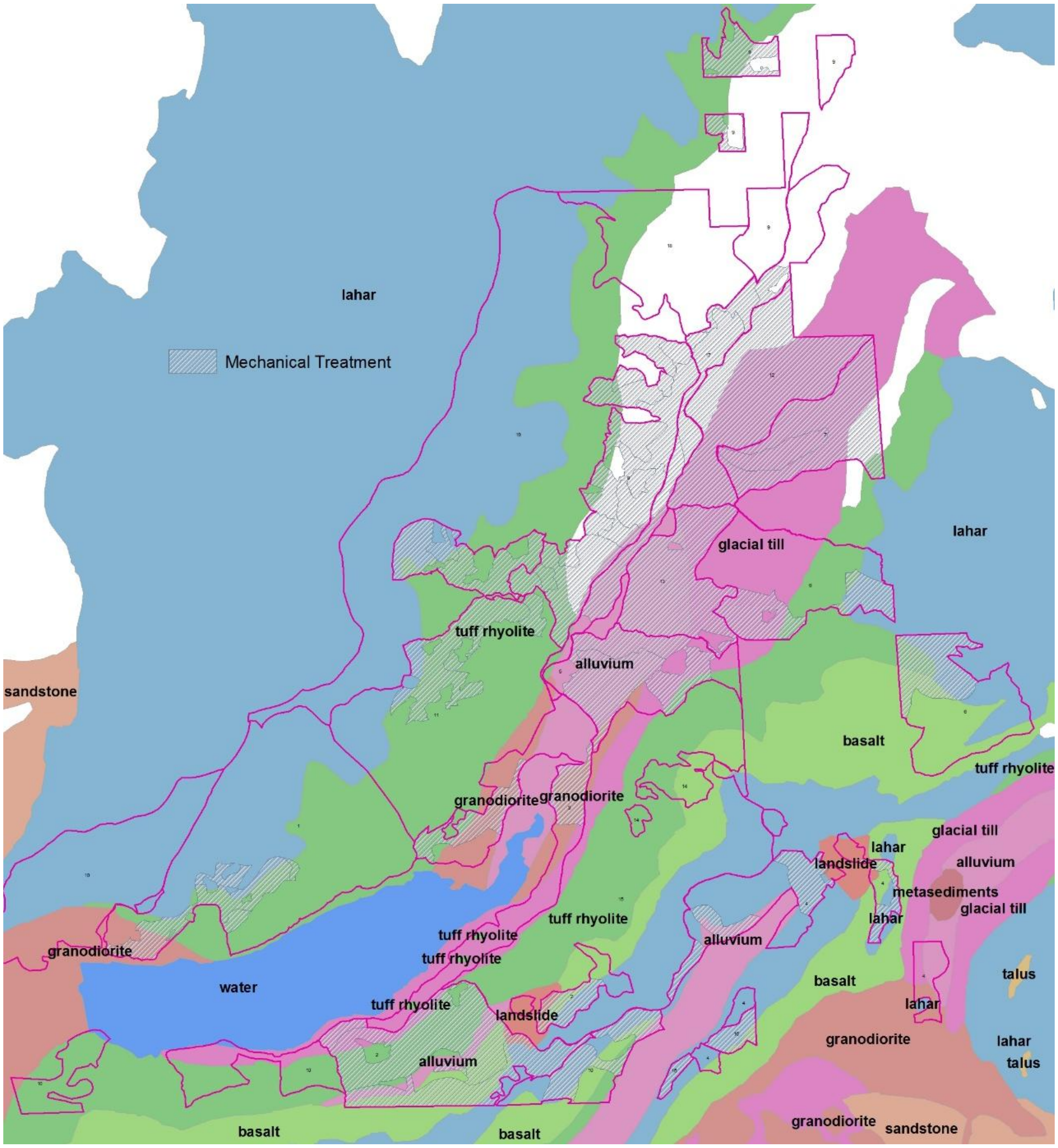

Figure 2 French Meadows units with mechanical treatment and geology

Roads

Secondary system roads, such as FS68, were frequently scoured by sheet wash to a gravel cobble base by last winter's runoff, and occasionally rutted when the aforementioned tuff member was the base surface. The severity of the runoff season was evidenced by numerous drainage paths from the contributing hill slopes that appeared newly initiated—rills and other evidence of scour without corresponding valley features, such as a swale. The roads are largely out-sloped, with occasional inboard ditches that appeared to have been designed to drain particularly wet hill slopes. Rolling dips were the most common road drainage feature, but were not spaced frequently enough for last winter's volume of runoff. Outside berms from periodic maintenance were common, and served to contain flow onto the running surface for long distances. Altogether about 3.7 miles of road (Table 2) were in need of reconditioning. Figure 3 shows places where either drainage features (mostly rolling dips) need maintenance or could be added to reduce rutting due to surface runoff.

Table 2. Road issues in French Meadows project

Road Number	Miles	Issues (Common to all roads listed)
042	0.93	Inadequately spaced drainage points, or engineered drainage points needing maintenance. Current engineered drainage almost exclusively in the form of rolling dips.
048-006	1.63	
068	1.15	
068-120	0.24	

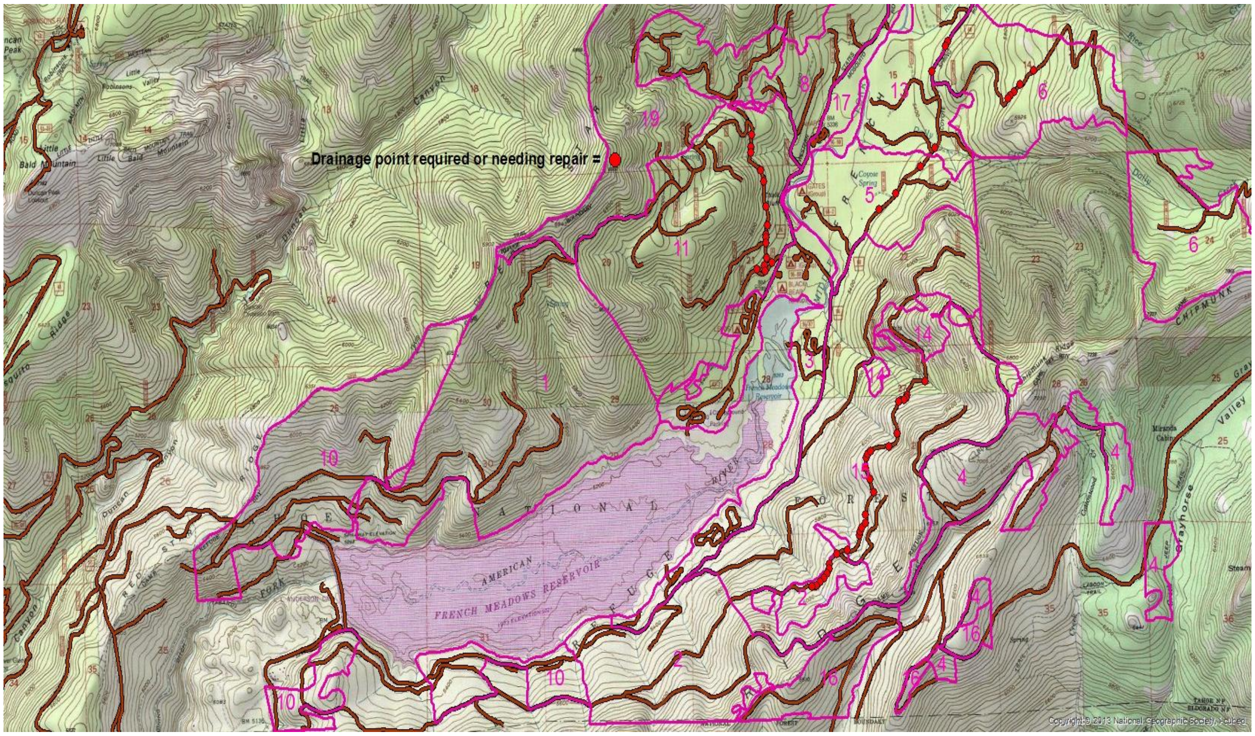

Figure 3 French Meadows roads and points of drainage needs, or repair of existing structure

Existing Incidence of Detrimental Disturbance

Table 3 shows results of survey for detrimentally disturbed ground and total soil cover, on units with proposed mechanical treatments.

Table 3. Percent soil disturbance and cover

Unit	Total Detrimental Disturbance (Percent of Unit Area)	Total Soil Cover (Percent of Unit Area)
1	5	78
2	13	87
5	5	92
6	6.6	95
7	5	87

Unit	Total Detrimental Disturbance (Percent of Unit Area)	Total Soil Cover (Percent of Unit Area)
8	8	92
11	3.3	88.3
12	11.7	83.4
13	10	87
15	8	93.4

Detrimental disturbance was mostly the result of sheet wash on secondary or tertiary haul routes, particularly on the glacial till, and not due to soil compaction. The trails were often scoured to a large gravel, cobble surface that resisted regrowth.

Total soil cover is excellent on an average basis in the units. Exceptions are in the large burn areas in units 1, 10, 18 and 19, on Red Star Ridge, that lie on the Mehrten Formation. This formation tends to have very thin soils with virtually no organics. It is typically poorly productive, with mostly shrubs and scattered, strongly tapered trees that are probably particularly susceptible to wildfire. It is a poor weather-resistant rock, so downslope of exposed Mehrten slope, wash fans are often thick and are the most productive in the project area. Soil cover under the mostly shrub mat (manzanita and whitethorn) was not systematically measured, but appears to be on average between 50 and 70 percent, mostly provided by overstory shrub canopy and very thin leaf litter.

Units 5, 12 and 13 are moraine based, loamy skeletal soils, with shallow slopes. Despite the stoniness, previous logging trails tend to be incised—the travel width is below the general surface of the ground, and lacking drainage, probably due to compaction of the soil. The extent of detrimental disturbance is high, perhaps because on the shallow slopes of these units there were few constraints to where equipment could travel. By contrast, most of the rest of the project area has steeper slopes and coarser texture made up of sandy loams, and compaction was not as high. Underlying geology in proposed mechanical operations units is mostly either granodiorites or flow rhyolites.

Steep slopes within mechanical prescription units were not common, largely confined to side slopes of draws (the inner gorge area) and relatively short slopes between topographic benches in the glacial till units. Exceptions were a large portion of the mastication area in Unit 15, and around the contact of the Mehrten formation and flow rhyolite on Red Star ridge in units 1, 10, 11, 18, and 19.

Small pockets of aspen were found in Unit 12. The river bottom units of 5, 12 and 13 had what might be referred to as deranged drainage of the low-lying terrace adjacent to the river, caused by somewhat arbitrary glacial deposition. Stringer and pocket meadows are common in these units, with at least one small basin that forms a seasonal pond.

The white tuff member of the rhyolite is frequently encountered in roadcuts, particularly on Red Star ridge, and causes relatively minor instances of hill slope sloughing. The same member induces a sizable spring in a roadcut in Unit 1, and may be responsible for other instances of seeps and/or slope instability.

Impaired Water Bodies

As required by the CWA, the California State Water Resources Control board releases biennial reports on impaired water bodies on their website at https://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2012.shtml (accessed February 2, 2018). Hell Hole Reservoir is the only Category 5 watershed in the assessed watersheds; it is at Category 5 for mercury levels. Mercury is a common contaminant in large reservoirs, the source believed to be atmospheric deposition from the burning of coal in electrification plants (Scudder et al. 2009). Category 5 requires a Total Maximum Daily Load (TMDL) assessment (TMDL is a threshold beyond which a project must not include areas with the listed pollutant without a mitigation plan). Completion date for the assessment is scheduled for 2021. Mercury is a common contaminate in large reservoirs, the source is believed to be atmospheric deposition from the burning of coal in electrification plants (Scudder et al 2007). Mercury combines with methane, an off gas from biotic reduction of buried organics, to form methyl mercury, a neuro-toxin that bio accumulates in fish (Driscoll et al 2007).

There are no category 4a or 4b water bodies in the project watersheds. Category 4a and 4b are impaired water bodies for which mitigation measures are being applied by either TMDL or other actions.

Environmental Consequences

Alternative 1 – Proposed Action Alternative

Direct and Indirect Effects

Direct effects include loss of ground cover, compaction and displacement of soil, and loss of canopy cover. Indirectly, loss of ground cover and displacement in the form of rutting can lead to surface runoff and erosion of soil surface layers.

Loss of canopy cover can increase evaporation, because of shading reduction, but research has shown the greater effect is in fact a decrease in transpiration, leading to increased soil moisture (Saksa et al., 2017). While increased soil moisture increases soil weight and under the right conditions can lead to landslips, a more typical response is increase in small peak flows, often in the autumn months, with recurrence intervals of well under 1 year (Grant et al. 2008, Saksa et al., 2017). The amount of canopy reduction for measureable gain in peak flows, however, in areas like the French Meadows project that have transient snow cover, is highly uncertain and may depend on actual prescription of the treatment itself.Long-term research on forested experimental watersheds that are outside the Sierra Nevada, mostly involving clear-cuts, suggest a minimum of 20% basal area reduction threshold for a detectable change in water yield (Bosch and Hewlett, 1982) or peak flows (Grant et al 2008). A more recent study at a similar elevation as that for this project in the American River Basin with heterogeneous thinning treatment indicates measurable streamflow changes with well below 20% basal area reduction threshold.

Most catchment studies are small basin, less than 200 acres, though the maximum size are much larger, about 3500 acres, and the generalizations stated above hold throughout this range (Troendle et al. 2001). Larger watersheds attenuate the management effects even further, possibly because of increasing resistance to flow with size (Grant et al. 2008). Table 4 outlines the total estimated canopy loss from baseline due to action alternatives for the French Meadows project, past and foreseeable projects, and permanent infrastructure such as roads.

The duration of effects depends on the nature of the treatment and site potential for regrowth (Conklin et al. 2015; Saksa, 2015). Depending on treatment type and climate, recovery from effects is usually within 5 years (Saksa 2015). By the end of that term, soil moisture flux studies show new vegetation largely uptakes available water, and evapotranspiration (water losses through soil evaporation and plant transpiration) may even exceed initial pre-cut stand condition (Simonin et al. 2007). For perennial conversion, however, it may take longer to ascertain long-term average. Further, studies suggest that the highest changes from woody canopy reduction are where subsurface flow is substantial (Huxman et al. 2005) and vegetation is not water limited (Saksa et al 2017).

The goal of the project mechanical thinning is to retain about 50 percent canopy closure, though this represents much less than 50 percent reduction of existing canopy.

McComb (2013) found an average of about 90 percent residual ground cover from monitoring of thinned units on TNF. Overall, the current survey found existing forest floor ground cover in the project area to be nearly continuous, well over 90 percent currently, with the exception of the brushy upper slopes of units 1, 10, 11, 18 and 19 on Red Star ridge.

Results of LANDFIRE modeling for the project area prescribed burn (Landscape Fire and Resource Management Planning Tools, https://www.landfire.gov/pls.php) project that a low severity burn can be expected in the shrub slopes of Red Star ridge (Brough et al. 2017). A low severity fire by definition is 25 percent or less top kill of existing canopy species, with unburned and burned organic cover remaining between 30 and 50 percent for the short term (3 year) recovery period. This amount of cover satisfies LRMP S&G #55 for soil productivity (see French Meadows Soil Report "Standards and Guidelines" section) and for protection against accelerated erosion of the soils occupying that area.

Total detrimental disturbance from ground-based harvest methods in Northwest United States forests was found by Jordani (2010) and Han et al. (2009) to be about 7 percent of the harvested ground. McComb (2103), monitoring TNF activity units, found detrimental compaction to average about 5 percent. TNF monitoring for 2016-2017 (Hunner 2017) found much higher rates of compaction –only 25 percent of monitored units were compliant. Close adherence to MRs, particularly S1 (soil moisture thresholds for equipment) and S4 (mitigation of compacted ground), is critical in keeping total compaction within thresholds. Most compaction on a site (60%) is found to occur within the first 5 passes of equipment (Han et al. 2009; Williamson and Nielson 2000), though the actual amount of compaction is affected by initial bulk density of the soil (Miller et al. 2010).

Mastication typically results in negligible compaction if reasonable care is taken to travel equipment on the resultant slash. The masticated material not only buffers against machine disturbance, but contributes soil cover as mulch (Hatchett et al. 2006). The study by Hatchett et al. (2006) was on some of the same soil types as the present project (Tallac-series coarse gravelly loam), and was conducted in the nearby Tahoe Basin.

Hand thinning and hand piling would have negligible effects to soil porosity. Pile burning can result in more intense soil heating, decreasing soil hydrologic functioning, and in degradation of soil physical properties directly beneath piles (Neary, 1999). Because these piles cover a small and scattered area, however, it is unlikely that soil porosity would decrease by a significant amount within a unit.

Table 4. Canopy loss due to vegetative management and permanent infrastructure

Watershed	Canopy Loss Due to Permanent Infrastructure		Canopy Loss Due to Vegetative Management	
	Alt 1	Alt 3	Alt 1	Alt 3
Chipmunk Creek	1.61	1.61	1.20	1.47
Dolly Creek	1.72	1.51	14.78	13.99
French Meadows	1.46	1.29	17.00	12.71
Lower Hell Hole	0.77	0.77	0.83	0.30
Rice Creek	1.43	1.29	10.50	9.36
Talbot Creek	0.09	0.09	0.02	0.03
S.F. Long Creek	1.59	1.59	3.77	2.21
Upper Hell Hole	0.46	0.46	0.43	0.08

Streamside Management Zones

Periodic review of research on the effect of streamside buffers for SMZ has found consistent results in terms of maintaining water quality (Castelle et al. 1994; Castelle et al. 2002; Fischer and Fischenich 2000). Forest floors present a relatively high resistance to shallow surface flow. Buffers of any vegetative type, of about 30 meters, will remove 80-90 percent of nutrient and sediment load, largely through resistance and dispersal of the transporting sheet wash.

Material of sand size or greater will deposit in a few meters or less, and then progressively longer distances are required for finer particles. Even at 30 meters, clay-sized particles will not be entirely winnowed out, and account for most of the material still entrained. Sediment will deposit in a strip at the beginning of a buffer until the cover is effectively buried. Then the sediment deposition area advances a few meters. Since nutrient elements are mostly bound to sediment, the first 10 meters is also the most effective for trapping nutrients.

The following stream management zones are established for the project as MR W1, compliant with the SNFPA.

Table 5. SMZ guidelines

Stream Type	Width of the Riparian Conservation Area
Perennial streams	300 feet each side, measured from bank--full edge
Seasonal flowing streams	150 feet each side, measured from bank--full edge
Streams in inner gorge	Top of inner gorge
Meadows, lakes, and springs	300 feet from edge of feature or riparian vegetation, whichever is greater

The main objective for MRs in regard to stream courses is to maintain integrity of the riparian reserves and connected network of small 0 order draws and swales that may be only ephemeral in nature. MR W2 establishes No Equipment Entry "riparian buffers" within the SMZ of 100-foot along each side of perennial streams and special aquatic features, 50-foot along each side of intermittent streams, and 25-foot along each side of ephemeral streams.

No ground-based equipment is allowed in riparian buffers, unless required for meadow, aspen, and cottonwood restoration, trail construction, or on an approved skid trail or road crossing. Consultation with a Forest Service hydrologist is required prior to constructing temporary roads across ephemeral or intermittent drainages (MR W14).

The potential effects of riparian buffer widths on streams were checked in the field for a number of units which were adjacent to or had SMZ running through them. Forest floor was found to be 90 to virtually 100 percent where natural conditions allowed (i.e., aside from outcrops or talus slopes). Based on results of research, and observation of post-activity effects by the author, the riparian buffer widths would be adequate for the primary function of preventing surface flow and transported sediment from upslope of channels entering the buffer zones.

Roads

The proposed project would add 2.1 miles of temporary road which, after project completion, would be returned to non-detrimental compaction and runoff conditions and closed. In addition, 7.6 miles of roads would be decommissioned. 20.8 miles of current system roads would receive maintenance, potentially improving drainage from the current condition. As the "Affected Environment" section of this report notes, approximately 3.7 miles of system roads that would be used to access activity units need additional drainage points. These improvements would mainly serve to reduce fine grain sediment road wash.

Fine grain (<0.005mm), mainly suspended sediment from road surface runoff is typically the largest component of road wash sediment and has the greatest direct effect on water quality (Bilby et al. 1989; Luce and Black 1999; Sugden and Woods 2007). The presence of this material is strongly and positively correlated to traffic and maintenance level. While re-grading of roads will often simply re-supply a road surface with loose material for transport, improved drainage can reduce the energy of surface wash and correspondingly its ability to transport material. Improvement of road drainage, particularly in the approach (within 100 feet) of perennial and intermittent stream crossings, will allow road wash to be passed onto slopes with a buffer in place, instead of being fed directly into the channel. This should substantially decrease the potential amounts of sediment entrained in area streams.

Runoff

Loss of canopy cover can increase evaporation, because of shading reduction, but research has shown the greater effect is in fact a decrease in transpiration, leading to increased soil moisture (Saksa 2017). A typical response is increase in small peak flows, often in the autumn months, with recurrence intervals of well under 1 year (Grant et al. 2008, Saska et al. 2017).

There is also evidence that canopy reduction from uplands would lead to increased runoff during snow melt, both in total yield and in peak flow (Troendle and King 1987; Burton 1997; Troendle et al. 2001). Open spaces frequently accumulate greater snow depth on the ground than areas with a forest canopy, which exposes less of the snow to solar radiation and wind (Geddes et al. 2005; Musselman et al. 2008). The canopy structure spreads snowfall over a greater surface area than it would occupy on the ground below. Forest harvesting in the Sierra Nevada have shown increases of 14-34% in snow accumulation (Bales et al., 2011). Also, the larger proportion of snow melt occurs while soil temperatures are cold enough to suppress plant activity and transpiration.

For the project area watersheds, the effect of the project is to slightly elevate total canopy loss—loss from permanent infrastructure and management past, current or future—on most of the watersheds. On a few watersheds, Dolly Creek, French Meadows Reservoir, and Rice Creek (see Table 4) canopy loss could be elevated to a level below but close to threshold. These changes are not expected to cause observable or measureable change in runoff regime, either in partial year peaks (small seasonal peaks), or in total annual yield. A research study is underway in the Dolly Creek and Rice Creek watersheds to understand the impact of forest restoration treatments on streamflow and forest water use using a Before-After-Control-Impact study design.

Note: Cumulative effects for all alternatives are discussed following Alternative 3.

Alternative 2 – No Action Alternative

Direct and Indirect Effects

Under the No Action alternative, none of the actions proposed in Alternative 1 would be implemented. This includes mechanical thinning, fuels reduction, aspen restoration, meadow restoration, under-burning, trail construction, road decommissioning, and removal of hazard trees and vegetation along distribution lines. Forest vegetation would continue in its current condition and trend. Fuels would only be modified through wildfires.

Under this alternative, routine land stewardship, including fire suppression, road maintenance, or other administrative activities that address threats to life and property, would continue.

Alternative 2 would have no direct effects on soil compaction/cover or canopy cover. System roads now in degraded condition would continue without maintenance, and would continue to concentrate near-hill-slope and road prism precipitation to discrete drainage locations.

Sediment wash from roads into stream channels, largely at points of crossing, would be mostly of sand size or smaller, transportable at higher flows if not base flow condition. In view of the frequently inadequate spacing of drainage features on project area system roads, and the rills developed by the 2017 runoff, it is the opinion of the author, based on personal field study (Moser 2017), that sediment load may very well be in the hundreds of pounds per season at many crossing locations. This is at least an order of magnitude above typical base level for moderate traffic level roads.

Alternative 3

Direct and Indirect Effects

The treatments prescribed for Alternative 3 are the same as for Alternative 1; only the distribution and total amounts have changed to accommodate spotted owl habitat. Table 6 shows differences between the two action alternatives. In essence, Alternative 3 reduces mechanical thinning by about 2,600 acres, with a nearly equal increase in hand thinning (973 acres) and prescribed burning (1,667 acres).

Table 6. Comparison of Alternative 1 and 3 treatment acreage

Treatment Type (Initial/Follow-up)	Acreage	
	Alternative 1	Alternative 3
Mechanical Thin/ Mechanical Fuels Treatment	1,496	529
Mechanical Thin/ Prescribed Fire	586	103
Thinning in Recreation Sites	136	136
Hand Thin	340	1313
Mastication Thin Natural	283	275
Mastication Thin Natural/ Prescribed Fire	83	83
Mastication Thin Plantation	655	597
Mechanical Thin Natural/ Mechanical Fuels Treatment	1,652	563
Mechanical Thin Natural/ Prescribed Fire	83	22
Mechanical Thin Plantation	152	114
Reforestation - Site Prep and Plant	102	102
Release Mastication	102	102
Release Mastication/ Prescribed Fire	308	308
Prescribed Fire	6,205	7,872

The important differences between the alternatives for soil productivity relate to soil compaction in units 2, 12 and 13, where mechanical thinning is largely replaced by hand thinning and relatively small amounts of under-burning. Compaction and soil disturbance, factors leading to accelerated runoff, would be reduced

In regard to ground cover, under-burning increases are proportionally greater in units 2 and 6. Each of these units is prescribed about 400 acres more burning in Alternative 3 than in Alternative 1, with a concomitant decrease in mechanical thinning. These effects are confined to French Meadows and Dolly Creek watersheds, and on that basis, the overall effect is a reduction in canopy loss in Alternative 3 over Alternative 1.

Approximately 7.6 miles fewer open, system roads would be re-conditioned in Alternative 3 than in Alternative 1, and half as many miles of temporary roads would be constructed (1.0 mile versus 2.1 miles). Temporary roads would be de-compacted with equipment and closed after use. All other road actions would be the same as in Alternative 1. With over 7 fewer miles of road re-conditioned (which may include increased drainage points), the potential sediment delivery to area streams remains higher than in Alternative 1.

Cumulative Effects, All Alternatives

Cumulative effects of the three alternatives can be analyzed by comparing the ERA assessment for each alternative. The ERA method does not have spatial elements in regards to canopy loss and/or ground disturbance, but simply ratios impacts to the whole watershed area under analysis. Effects to stream shading, and consequently to stream temperature, are not modeled, but rely on assumptions of effectiveness of best management practice and project design features, including stream buffers that will maintain shading at current levels.

Almost all of the impacts of future and foreseeable projects in the assessed watersheds would be due to the French Meadows project. The single exception is King Fire salvage and projections of yearly harvest on private land, based on Timber Harvest Plans, which are environmental review documents submitted to CAL Fire, California Department of Forestry and Fire Protection. Table 4 outlines present condition as percent ERA for the project year, projecting forward for three years for the No Action alternative. The threshold of concern (TOC) for each assessed watershed is provided as a point of comparison. Another assumption for these model runs is that all project work would be completed in the first project year, the so-called “worst case” to assess for maximum possible impact.

The results of the ERA model runs are presented in order as Alternative 2—no action, Alternative 1—proposed action, and Alternative 3, modified action. It can be seen that no watershed has impacts greater than 67 percent of threshold (Dolly Creek, Alternative 1). Most of the activity takes place in three watersheds: Dolly Creek, French Meadows Reservoir, and Rice Creek. For most of the analyzed watersheds, the impacts do not drive % ERA much above current rates. It is not expected that there would be any measurable or observable impacts related to flow regime or channel condition in the downstream reach of any of the project watersheds analyzed. The results of the ERA analysis agree with expected results from estimates of canopy reduction.

Table 7. Alternative 2 -- % ERA

Watershed	Acres	TOC as % ERA	Current Year % ERA	First and Second Year, Post-Activity % ERA	
			2018	2019	2020
French Meadow Reservoir	6962	12	3.5	3.3	3.0
Lower Hell Hole Reservoir	6106	10	2.7	2.5	2.5
Chipmunk Creek	7399	10	2.6	2.5	2.5
Dolly Creek	4964	12	3.9	3.8	3.4
Rice Creek	7543	12	3.0	2.9	2.6
Talbot Creek	4932	10	1.3	1.5	1.4
S.F. Long Creek	7118	10	4.8	4.6	4.2
Upper Hell Hole Reservoir	5147	10	0.8	0.8	0.8

Table 8. Alternative 1 -- % ERA

Watershed	Acres	TOC as % ERA	Current Year % ERA	First and Second Year, Post-Activity % ERA	
			2018	2019	2020
French Meadow Reservoir	6962	12	3.5	6.5	5.1
Lower Hell Hole Reservoir	6106	10	2.7	2.8	2.7
Chipmunk Creek	7399	10	2.6	2.8	2.5
Dolly Creek	4964	12	3.9	8.3	8.0
Rice Creek	7543	12	3.0	5.8	5.8
Talbot Creek	4932	10	1.3	1.5	1.4
S.F. Long Creek	7118	10	4.8	4.6	4.2
Upper Hell Hole Reservoir	5147	10	0.8	0.8	0.8

Table 9. Alternative 3 -- % ERA

Watershed	Acres	TOC as % ERA	Current Year % ERA	First and Second Year, Post-Activity % ERA	
			2018	2019	2020
French Meadow Reservoir	6962	12	3.5	4.2	3.1
Lower Hell Hole Reservoir	6106	10	2.7	2.7	2.6
Chipmunk Creek	7399	10	2.6	2.8	2.5
Dolly Creek	4964	12	3.9	5.9	4.8
Rice Creek	7543	12	3.0	4.1	3.5
Talbot Creek	4932	10	1.3	1.4	1.3
S.F. Long Creek	7118	10	4.8	5.3	4.7
Upper Hell Hole Reservoir	5147	10	0.8	0.8	0.8

Hell Hole Reservoir is listed in State of California 303(d) as Category 5 for excess concentrations of mercury. The most significant contributing area is probably the surrounding watershed, and sediment eroded into the lake, because it carries elemental mercury deposited from the atmosphere (Mason et al. 1994). In the reservoir, a reaction of elemental mercury with methane produced from biotic reduction of sulfides in anaerobic conditions creates methyl mercury, a particularly acute neurotoxin (Scudder et al. 2009). Part of the reason reservoirs have been found to be especially vulnerable to creation of methyl mercury is widely fluctuating water levels and rapid accumulations of sediment, leading to burial of organic material. The methyl mercury bioaccumulates in fish to levels 1 to 10 million times concentration in the water column. By the time the methyl mercury reaches the tissue of top predator fish, it can lead to serious health issues as a result of the consumption of fish (Driscoll et al. 2007).

Proposed treatments in both alternatives, in regard to Hell Hole Reservoir watershed, are the same as for those types of impacts that might lead to accelerated erosion: mechanical thinning operations and under-burning. The amount of impacted ground is 96 acres of thinning and 26 acres of burning, or about 1 percent of the total area. This is not expected to be a significant contribution to mercury pollutant.

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Appendix

The four components of the Aquatic Conservation Strategy are: 1) establishment and management of Riparian Reserves, 2) Key Watersheds, 3) Watershed Analysis, and 4) Watershed Restoration. There are also nine objectives that are evaluated to determine whether a project or management action "meets" or "does not prevent attainment" of the ACS objectives.

Objective 1. Maintain and restore the distribution, diversity, and complexity of watershed and landscape-scale features to ensure protection of the aquatic systems to which species, populations and communities are uniquely adapted.

Alternatives 1 and 3. Treatments within Riparian Reserves would preserve species diversity, and larger trees that possibly would more closely resemble historical conditions. These changes in turn could result in an improved trend for stream shading by improving growth potential of larger trees.

Objective 2. Maintain and restore spatial and temporal connectivity within and between watersheds. Lateral, longitudinal, and drainage network connections include floodplains, wetlands, upslope areas, headwater tributaries, and intact refugia. These network connections must provide chemically and physically unobstructed routes to areas critical for fulfilling life history requirements of aquatic and riparian-dependent species.

Alternatives 1 and 3: Proposed treatments would not directly impact the connectivity between watersheds or individual drainages. Proposed activities do not result in any physical barriers to channels.

Objective 3. Maintain and restore the physical integrity of the aquatic system, including shorelines, banks, and bottom configurations.

Alternatives 1 and 3: Mechanical equipment is excluded from the vicinity of streambanks (25-100 feet depending on flow regime). Peak flows are not expected to increase due to canopy reduction or compaction, so increased channel cutting is not anticipated.

Objective 4. Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities.

Alternatives 1 and 3: Water quality of streams within the project area would be maintained under either action alternative. Stream shading would not be affected, so no increase in stream temperatures is expected. Likewise, flow regime, either peak flows or annual yield, are not expected to be measurably affected. Refueling and maintenance of motorized equipment would occur away from any stream channel, spring or seep. Road reconditioning, insofar as drainage points are increased, could result in decrease of sediment delivery directly to channels at road crossings.

Objective 5. Maintain and restore the sediment regime under which aquatic ecosystems evolved. Elements of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport.

Alternatives 1 and 3: No long-term increases in either erosion at the site of project activities or sediment delivery to stream channels and other aquatic species habitats are expected for either action alternative. Natural slope buffers to streams are adequate to prevent initiation of surface erosion or to arrest surface flow and delivery of sediment to channels.

Objective 6. Maintain and restore instream flows sufficient to create and sustain riparian, aquatic, and wetland habitats and to retain patterns of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of peak, high and low flows must be protected.

Alternatives 1 and 3: It is unlikely that proposed activities under either action alternative would cause detectable changes in instream flows, as project activities have little potential to reduce canopy and compact ground to levels exceeding thresholds that would result in detectable changes in flow regime, either peak flow or annual yield. The proposed and foreseeable projects likewise do not constitute enough canopy reduction and ground disturbance to lead to expected changes in runoff, based on available research.

Objective 7. Maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows and wetlands.

Alternatives 1 and 3: Floodplains, meadows, and wetlands are all included within Riparian Reserves. Design features and BMPs restrict disturbance activities within these areas. No ground-disturbing activities would take place within these areas, and the proposed activities would not affect timing, variability, and duration of floodplain inundation. Meadow enhancement—thinning and removal of conifer encroaching on aspen stands--will also be done, but as this area constitutes only about 70 acres, largely in units 12 and 13, there is no expected measureable effect either in terms of runoff or sediment production.

Objective 8. Maintain and restore the species composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and to supply amounts and distributions of coarse woody debris sufficient to sustain physical complexity and stability.

Alternatives 1 and 3: Vegetation treatments in Riparian Reserves, including low severity backing fire, would remove accumulated ground and dead fuels, and dense low-growing understory vegetation, with the intent of eliminating ladder fuels and reducing the threat of a crown fire. Large overstory vegetation would remain intact and would continue to provide thermal regulation. In the long term, treatments in Riparian Reserves are expected to promote the growth of larger conifer and hardwood species already present, resulting in a more diverse forest structure and a source of coarse woody debris.

Objective 9. Maintain and restore habitat to support well-distributed populations of native plant, invertebrate and vertebrate riparian-dependent species.

Alternatives 1 and 3: The proposed treatments in the action alternatives are designed to reduce fuel loading and move the fire regime closer to that which occurred historically on the landscape and within Riparian Reserves. Beneficial effects to riparian and aquatic habitat are expected in the long term.